

**CHIPS AND  
OTHER FOOD ITEMS  
FROM DEEP-FAT  
FRIED MUSHROOMS**

# CHIPS AND OTHER FOOD ITEMS FROM DEEP-FAT FRIED MUSHROOMS

By

Reba B. Greenspun\*, Edward G. Kelley\*\*, and W. L. Porter\*\*\*

## ABSTRACT

Mushroom slices were cooked by a French-frying process similar to that used in the preparation of beet, carrot and parsnip chips, pea and lima bean nuggets, and sweetpotato chips.

Various sizes were used, from buttons to overmature mushrooms. Special attention was given to the larger mushrooms generally considered to be commercially unacceptable.

Cooking conditions are described and the moisture content before and after frying are reported. Data on yield, oil content and protein content are also presented.

Rehydration of the chips and their use in the preparation of soups and sauces are described.

The deep-fat frying of a number of vegetables in the form of whole pieces, cut pieces, and chips has been investigated by this laboratory (6, 7). \*\*\*\* Although mushrooms are not a vegetable, they are often used as a vegetable substitute and were considered as a possible source of a new and useful chip.

More than 60 percent of the 165-million pound, 50-million dollar per year mushroom industry is concentrated within a 50-mile radius of Kennett Square, Pa. Supplies of mushrooms are, therefore, readily available to this laboratory in all stages of maturity throughout most of the year.

Considerable literature exists on the culture of mushrooms, both on compost (1) and in liquid broth (3). Some nutritional studies have also been made on Agaricus campestris (5, 6), the species commonly grown by the American mushroom industry. Mushrooms are generally canned as buttons or slices and are sold on the fresh market for cooking in their own juice or sautéing in oil. They are often chopped and cooked for sauces and soups. Dried mushrooms are quite commonly imported from European countries. Brunell et al. (2) described methods for quick freezing and dehydrating mushrooms. Freeze-dried preparations are now available. No information has been found concerning the deep-fat frying of whole or sliced mushrooms for use as snack items or as material in commercially prepared sauces or soups.

---

\* Physical Science Technician, retired.

\*\* Deceased.

\*\*\* Head, Potato and Other Vegetable Investigations, Plant Products Laboratory.

\*\*\*\* Underscored figures in parenthesis refer to Literature Cited at end of this report.

Commercial mushroom growers attempt to harvest their crop in the smaller sizes ranging from buttons to specials (4). Unless the growing houses are air-conditioned, warm weather sometimes causes such rapid growth that a sizable part of a total crop becomes too mature for canning or fresh market uses. Part of the experimental work described in this report was carried out using these overmature mushrooms.

## EXPERIMENTAL PROCEDURE

### Sources of Material

The mushrooms used in these studies were obtained from three sources -

(1) The Mushroom Growers' Cooperative near Wilmington, Del., supplied two lots. Each lot had mixed sizes that ranged from buttons to overmature open gill caps up to 5.5 inches in diameter.

(2) Another lot of mushrooms was obtained from a commercial wholesale house in 3-pound baskets. These were labeled "specials" and were of a large size, about 2.5 inches in diameter with closed veils, generally used in commercial packs. They were grown on a farm near Kennett Square, Pa.

(3) The last two lots were supplied by a mushroom canning company near West Chester, Pa., and were grown under special experimental conditions that produced large uniform caps up to 3.5 inches in diameter. They consisted of both white and pink varieties, had both intact and broken veils, and had well-developed gill sections.

### Description of the Raw Material

With the exception of the commercial packs, materials were obtained on the day harvested and were transported to the laboratory within a few hours. Since raw mushrooms do not change rapidly, the material was kept in cool room storage (50°F.) for 4 or 5 days following picking. The commercial pack was received within 2 days after harvest and likewise was kept in cool storage.

All of the raw material contained variable amounts of residual soil or compost on the stipe (stem) end, which was not removed until time for preparation of the fried product. Because they were somewhat cleaner, the commercial packs were assumed to have been washed at the packing plant prior to shipment.

The average moisture content of raw mushrooms received from the growers' cooperative was 90.6 percent; that from the commercial source, 90.8 percent; and that from the experimental beds, 89.7 percent.

### Equipment and Frying Medium

The equipment described in the work of Kelley and others (7, 8) on vegetable chips was also used in this study. It consisted of a thickness-adjustable electric vegetable slicer, a thermostatically controlled frying kettle of 15-pound oil capacity, and a basket-type centrifuge. The modified coconut oil frying medium known as Fri-Fri\*, also discussed in the previous reports, was a

---

\* Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

product of E. F. Drew & Co., Inc., Boonton, N. J.

### Preparation of Fried Products

The mushrooms were removed from cool storage and weighed without washing. After rinsing thoroughly under a tap-water spray, they were placed on absorbent paper or a wire-screen surface to drain for 10 minutes. There was a 5- to 16-percent debris loss as the result of washing. Suitable quantities of mushrooms were removed and weighed for whole slicing or for separation into caps and stipes. In various experiments, three fractions were collected at the time of slicing: (1) the top  $1/4$  to  $3/8$  of an inch of the cap, (2) the lower section containing the major portion of the gill area, and (3) the stipe. In addition, the whole mushroom was sliced from the top of the cap to the bottom of the stipe, and the slices were mixed before frying. Weights were obtained on all fractions before and after frying.

The whole mushrooms and pieces were sliced in thicknesses of  $1/32$  and  $1/16$  of an inch for various studies. By carefully lining up the pieces in the feed trough of the vegetable cutter, uniformly cut slices could be obtained.

Slices were weighed, placed in frying baskets, and cooked for periods that ranged from 3 to 12 minutes and at temperatures that ranged from  $275^{\circ}$  to  $350^{\circ}\text{F}$ . Optimum frying times and temperatures were determined by subjecting individual samples to trials by an informal taste panel. Each lot of mushrooms was tested for best frying conditions, but all lots were found to be closely similar in characteristics.

Mushroom chips, like the vegetable chips described in the work of Kelley and Baum (7), rehydrate rapidly in boiling water. This characteristic makes dehydrated mushrooms an excellent product for use in soups, sauces, and pastes.

Two experimental soups were made from deep-fat fried chips. One was a cream of mushroom soup that was prepared by rehydrating fried chips in boiling water and then adding the mixture to a white sauce. The other, a pureed soup, was prepared by pulverizing mushroom chips for 0.5 to 1.0 minutes in hot water in a Waring Blender. This mixture was then added to white sauce. Both soups were high in mushroom flavor and, according to the taste panel result, of excellent quality.

### RESULTS AND DISCUSSION

Mature, fresh mushrooms were sliced in thicknesses of  $1/16$  or  $1/32$  of an inch, fried in deep fat at temperatures of  $275^{\circ}$  and  $300^{\circ}\text{F}$ . for 3 to 7 minutes, and made into crisp, fully flavored mushroom chips. Over a period of several years, the chips have been tasted by hundreds of people in laboratory panel tests, by groups of visitors, and by individual visitors. In all cases the chips were adjudged to have excellent flavor and consistency.

The flavor of the mushroom chips is between the rich taste of the mushroom cooked in its own juice and that of the skillet-fried pieces, depending upon the time and temperature used in deep-fat frying. It can be described as a fully flavored mushroom taste.

The flavor of mushrooms should be further explained, because we believe that the mushroom has several different flavors depending upon the amount and

method of cooking. Tasters have recognized the difference between these flavors in Agaricus campestris used in these studies. Steam- or hot-water-blanching pieces have a delicate, distinctive flavor and are generally used for canning, for preparing salads and creamed dishes, or for further cooking by frying and other methods. Compared with this delicate flavor, the mushroom, cooked in its own juice in the presence of a small amount of vegetable oil or fat at about the temperature of boiling water, has a rich, full-bodied, almost sharp flavor. Finally, there is the rich, strong flavor of the fried mushroom that has been prepared in a skillet with oil or fat and at a temperature considerably higher than that of boiling water (probably ranging from 300° to 450°F.). Mushrooms prepared this way usually have a slightly scorched or caramelized flavor, which is sometimes slightly bitter.

Exploratory studies indicated that mushroom chips were best when made from slices 1/32 of an inch thick that had been fried for 3 to 7 minutes at temperatures that ranged from 275° to 300°F. Chips made from slices 1/32 of an inch thick were consistently crisper than those made from slices 1/16 of an inch thick.

Data on yield, moisture, fat, and protein provided information as follows:

Lot 1 consisted of button size, medium, and large mushrooms. Its average yields (percentage of fried weight to fresh weight) were: button size, 22.8 percent; medium size, 17.9 percent; and large size, 20.6 percent. The average oil content was: button size, 60.45 percent; medium size, 57.6 percent; and large size, 61.3 percent.

Lot 2 was obtained from a wholesale house as uniform "specials" about 2-1/2 inches in diameter with closed veils. Its average yield of the fried product was 22.4 percent of the fresh weight; the oil content averaged 62.8 percent of the fried weight. In this lot of mushrooms, 1/32-inch slices of caps, gill sections, and stipes were fried separately. The fresh proportion and fried yields were as follows: Caps (30.6 percent of the whole) produced fried chips equal to 24.5 percent of the fresh weight; gills (39.3 percent of whole), 25.1 percent; and stipes (24 percent of whole), 24.2 percent. Taste evaluation of the fried fractions in lot No. 2 showed that most of the mushroom flavor was in the gill sections. This may explain why overmature mushrooms with large gill sections generally are considered to have a more acceptable mushroom flavor than other types. Therefore, it would seem that the large mushrooms, heretofore considered to be unacceptable, may well be utilized commercially by this method.

Lot 3 consisted of large 2.5- to 4-inch mushrooms considered to be overmature. It gave fairly uniform yields, which averaged 20.0 percent of the fresh weight. The average oil content was 55.8 percent.

Lot 4 consisted of white- and pink-variety experimental mushrooms that had been grown to 3.0 to 3.5 inches in diameter and were of uniform size. The white variety yielded 20.4 percent of fried product based upon fresh weight and had an oil content of 48.4 percent. The pink variety yielded 20.2 percent of fried product and had an oil content of 50.5 percent.

A complete study was made on lot 4 (table 1). In addition to yield and oil content, moisture and nitrogen (protein) were determined. Before frying, the moisture content averaged 90 percent; frying reduced it to 1.09 percent. The only difference detected between the pink (lot 5) and white varieties was in the color of the chips. The pink variety produced darker chips than the white variety.

TABLE 1. -- Description of samples and analyses of experimentally grown mushrooms

Description of Mushroom	Average moisture content		Frying conditions		Average yield, slices to		Oil content		Protein	
	Fresh Percent	After frying Percent	Temperature °F	Time Minutes	fried	Percent	Percent	Percent	As is basis Percent	Fat Free basis Percent
White, lot No. 4	91.1	1.25	275	7	18.32		43.86	19.81	36.12	
	88.8	-	275	7	20.30		-	-	-	-
	90.2	-	275	6	22.80		-	-	-	-
	90.2	-	275	7	22.18		-	-	-	-
	91.1	1.26	300	5-1/2	19.11		49.05	18.06	36.37	
Pink, (closed veil), lot No. 4	88.8	1.32	275	6	20.15		49.72	18.81	38.37	
	88.8	.802	300	6	21.14		50.81	18.69	37.44	
	89.2	1.18	275	7	20.82		49.63	16.75	34.06	
Pink, (open veil), lot No. 4		1.09	300	6	22.42		48.51	16.31	32.37	
	88.6	1.32	275	7	19.05		48.03	17.5	34.56	
		.519	300	6	19.84		54.61	15.25	34.00	

Mushrooms, like vegetables with an original high moisture content, absorb considerable oil (table 2). The values of oil content are based on the fried chips. There is also a correlation between the frying conditions and the amount of oil absorbed. For example, less cooking produced chips that were oilier than those fried for longer periods of time (table 2). All chips were considered acceptable, but preference varied with the taster. Chips cooked least were slightly toasted and retained more mushroom flavor than those cooked for a longer period.

Based on ratings by visitors and the test panel, the authors believe that the more thoroughly toasted slices are suitable for use as chips, whereas the least-fried slices, which are good in flavor and high in oil, are best suited for the preparation of soups and sauces. The high oil content of the least-fried chips can be lowered and make the product suitable for use as a snack chip. Lowering the oil content can be accomplished by centrifuging the chips in a basket-type centrifuge for 5 minutes at a speed of 1,500 r.p.m.

TABLE 2 - - Sample description, frying conditions, yield, and oil content of mushroom chips

Sample*	Size or color	Frying conditions**		Yield***	Oil content
		Temper- ature	Time		
		<u>°F.</u>	<u>Minutes</u>	<u>Percent</u>	<u>Percent</u>
Lot No. 1	Large	275	5	20.1	57.2
		300	4	20.6	65.4
	Medium	275	5	17.6	55.1
		300	3.5	17.8	60.2
	Buttons	275	5	20.7	57.8
		300	3.5-4	24.0	63.1
Lot No. 2	----	275	4	18.8	53.4
		275	5	19.4	55.2
		275	6	17.1	55.6
		300	3	22.1	57.2
		300	4	20.5	57.3
Lot No. 3	----	275	5	21.4	62.8
		300	3	22.2	62.8
Lot No. 4	White	275	6	20.2	49.7
		275	7	18.6	43.9
		300	5.5	18.3	49.1
		300	6	21.5	50.8
Lot No. 5	Pink	275	7	19.4	49.4
		300	6	20.9	51.5

\* Lot No. 1, Mushroom Growers' Cooperative No. 1; Lot No. 2, Mushroom Growers' Cooperative No. 2; Lot No. 3, Commercial Growers; Lot Nos. 4 and 5, mushroom canning company.

\*\* All slices 1/32 of an inch thick.

\*\*\* Yield is percentage of fried weight to fresh weight.

The relatively high protein content, averaging 17.6 percent on an as is basis, can be expected because the fresh mushroom contains approximately 2.4 percent protein (on a fresh basis). The high protein in mushrooms is of nutritional importance and should be considered when evaluating these products for soups, sauces, and other uses.

#### STORAGE OF CHIPS

Air-packed mushroom chips remain crisp and retain their flavor with little or no deterioration for more than a year if stored in airtight containers in the absence of light. If for some reason the chips become soft, crispness can be restored by heating them in a warm oven (approximately 250°F.) for several minutes.

#### LITERATURE CITED

- (1) Block, S. S., Tsao, G., and Han, L.  
1959. Production of mushrooms from sawdust. Fla. Engin. and Indus. Expt. Sta. Tech. Paper 158.
  - (2) Brunell, H. J., Esselen, W. B., Jr., and Griffiths, F. P.  
1943. Methods for quick freezing and dehydrating mushrooms. Food Indus., p. 74 (November).
  - (3) Eddy, B. P.  
1958. Production of mushroom mycelium by submerged cultivation. Jour. Sci. Food and Agr. 9: 644-649.
  - (4) Esselen, W. B., Jr., and Fellers, C. R.  
1946. Mushrooms for food and flavor. Mass. Agr. Expt. Sta. Bul. 434.
  - (5) Filios, A. M., and Esselen, W. B., Jr.  
1946. The vitamin content of canned and cooked fresh mushrooms. Jour. Amer. Dietet. Assoc. 22: 772.
  - (6) Fitzpatrick, W. H., Esselen, W. B., Jr., and Weir, Edith.  
1946. Composition and nutrient value of mushroom protein. Jour. Amer. Dietet. Assoc. 22: 318.
  - (7) Kelley, E. G., and Baum, R. R.  
1955. Preparation of tasty vegetable products by deep-fat frying. Food Technol. 9: 388.
  - (8) Kelley, E. G., Baum, R. R., and Woodward, C. F.  
1958. Preparation of new and improved products from eastern (dry-type) sweetpotatoes: chips, dice, julienne strips, and frozen-fries. Food Technol. 12: 510.
- 

REPORT OF WORK DONE AT  
Eastern Utilization Research and Development Division  
Agricultural Research Service  
U. S. Department of Agriculture  
600 East Mermaid Lane  
Philadelphia, Pa., 19118